# Predicting the Effect of Climate Change on a Marine Snail

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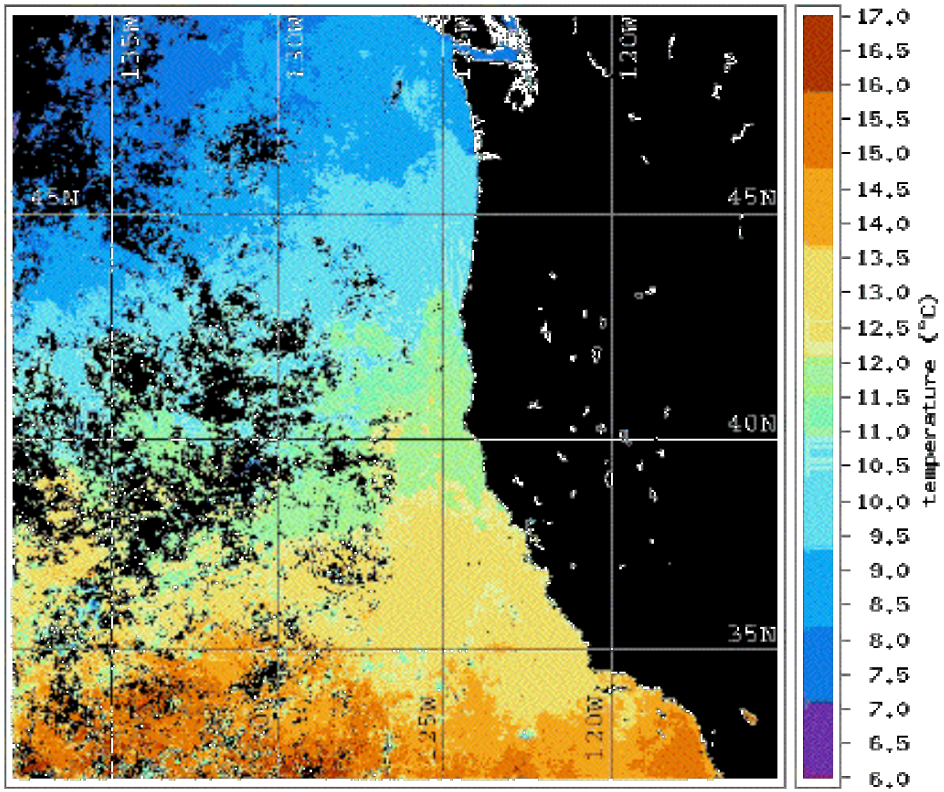
Although we are fairly certain that the climate is changing; we are only beginning to address the issue of how climate change will affect biological species and ecosystems. My research attempts to predict the response of an intertidal snail to climate change, specifically global warming, by examining the factors that determine the northern limit of its present geographic distribution.

# How will species respond to climate change?

CoastWatch Satellite NOAA-14 & 15 Data for February 2000
Sea-surface-temperature / West Coast Synoptic Region

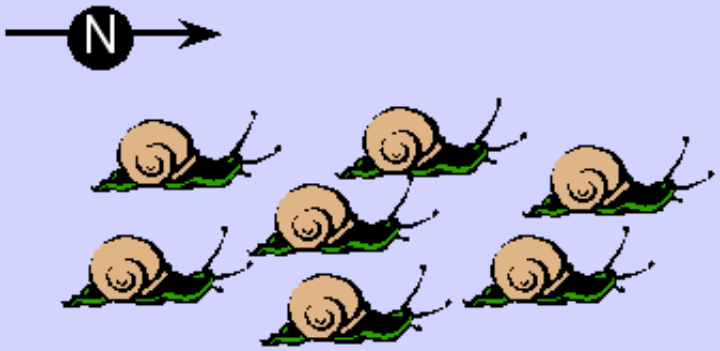



The figure at left shows sea surface temperature for February 2000, from NOAA satellite data. This figure clearly shows that water temperatures decrease with latitude along the west coast of the United States.

This leads to a very simple prediction: species and communities in the northern hemisphere will simply migrate north as the climate warms up.

source: http://www.cwatchwc.ucsd.edu

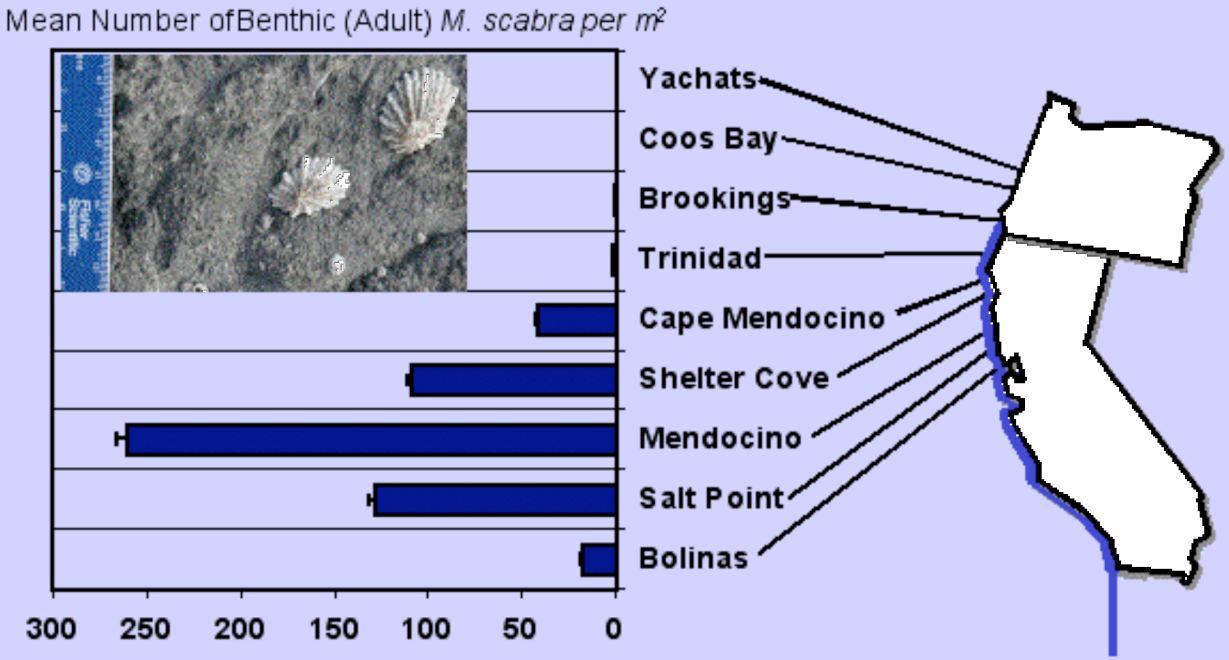
# But….





…other factors will affect the ability of species tomigrate poleward to track climate, such as: physiological tolerances, dispersal ability, and interactions with other species. So the impact of climate change on both species and ecosystems can be very complex.

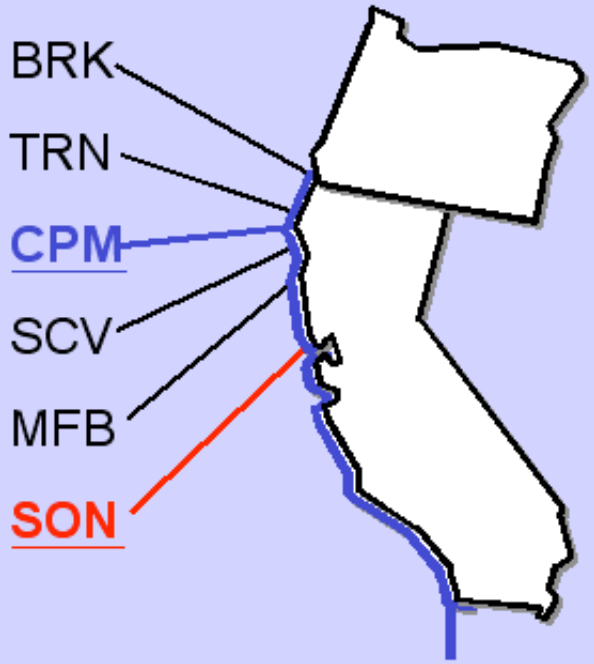
# Northern Distribution of *Macclintockia scabra*




My research directly tests the hypothesis that species will migrate north in response to climate change by examining the factors that determine the northern range limit of the intertidal snail *Macclintockia scabra*

The advantage of using a coastal species is that its distribution is compressed along the continental margin and it can only respond to climate change by moving north or south.

# Transplant Experiment




**RATIONALE:**

***If the northern limit is set by climate:***

Snails transplanted north of CPM will do worse than those transplanted south of CPM

***If other factors are more important:***

There will be no relationship between latitude and performance

To test whether snails do not occur north of Cape Mendocino because they cannot grow or survive, I conducted a transplant experiment. I collected 320 snails from each of two locations: Cape Mendocino, near the edge of the range; and, Bodega Bay, near the center of the range. I individually tagged, measured, and weighed each snail and transplanted 80 snails from each source to each of four transplant sites. Two sites (Brookings, OR and Trinidad, CA) were north of the range limit and the remaining two were inside the species' range.

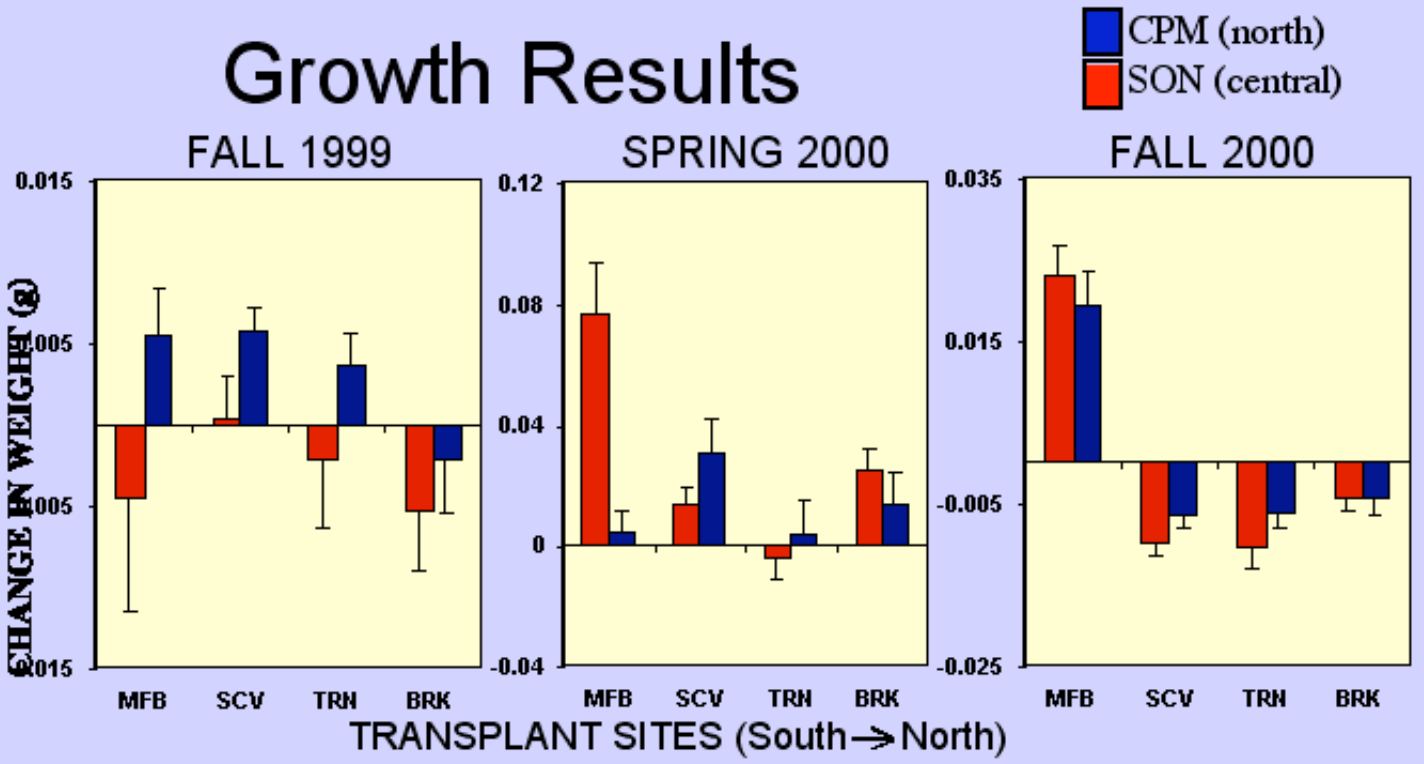
# A Transplant Site

At each of my four transplant site, I set out 20 cages of 8 snails. All of the snails within a cage came from either the Cape Mendocino or Bodega Bay source population.

The cages were constructed from plywood, terra cotta tiles, and polyethylene mesh.

I set the cages in five blocks of four on rocky reefs at each site. Each cage was bolted down at each corner with a #10 x 1 1/2" stainless steell bolt, anchored into the rock.

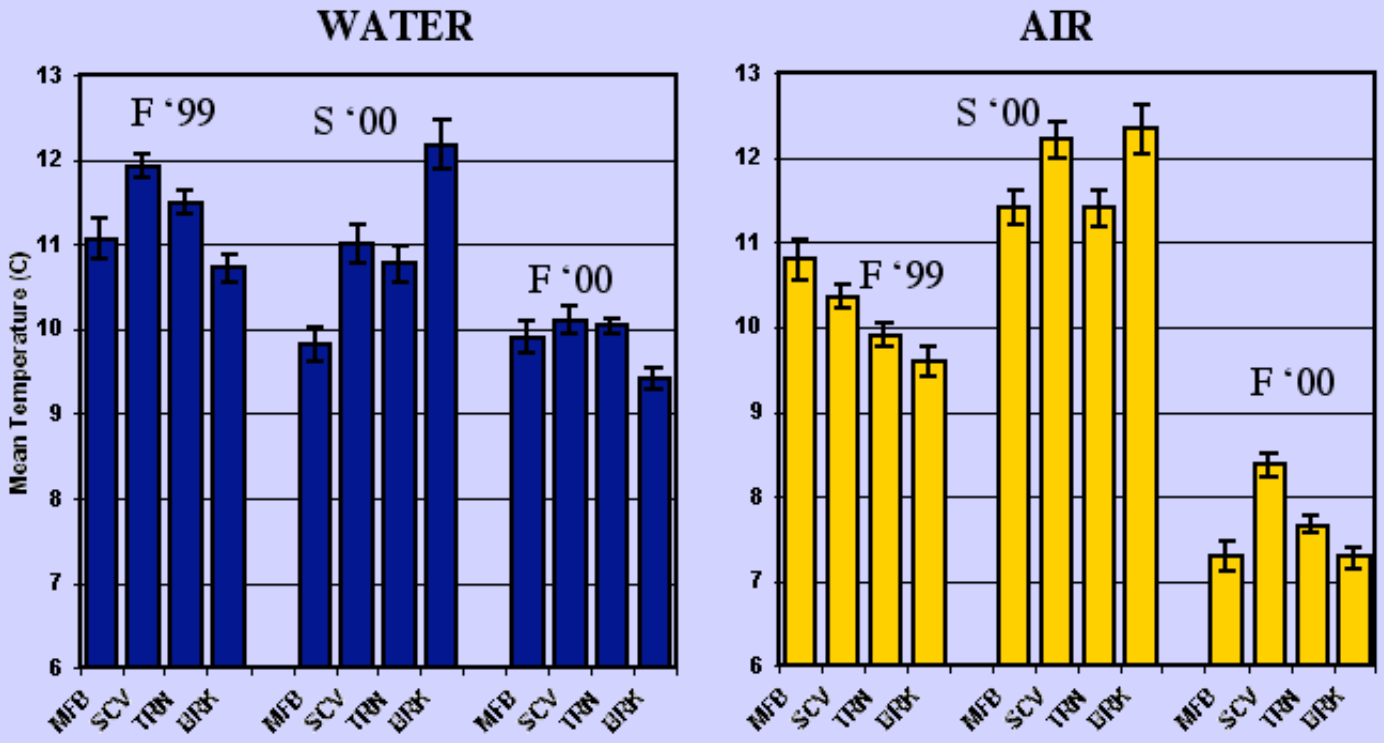
# Growth Results




I ran three transplant experiments from October 1999 through January 2001. At the end of each experiment I reweighed each snail and analyzed changes in weight with an ANCOVA.

Here I have plotted change in weight by source population (different colors) and transplant site (ordered from South to North along the x-axis) for each of the three experiments. If climate were important, I would expect to see significantly lower rates of growth for both source poplutaitons at the two northern transplant sites. Instead I see highly variable amounts of growth among season, source population, and transplant site, with no consistent pattern.

# Average Night Temperature

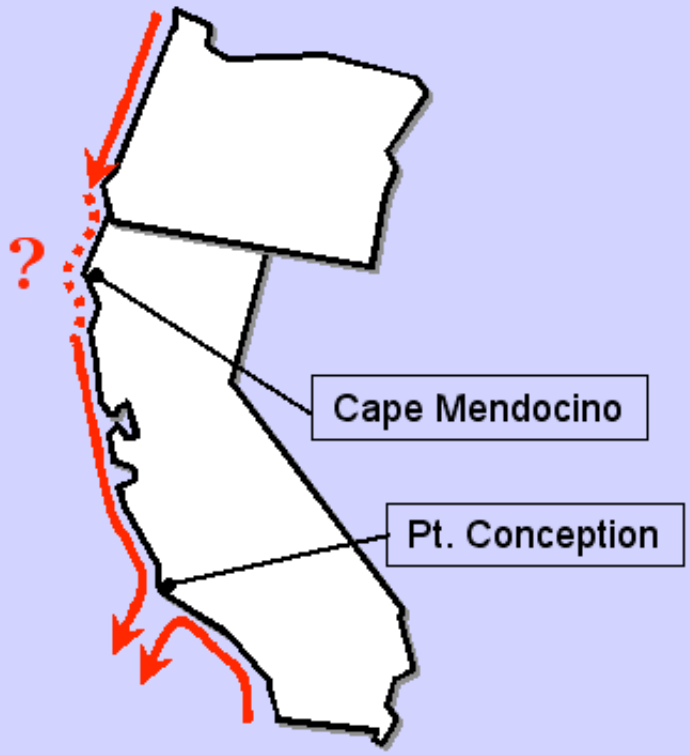



One reason that growth rates did match the predictions may be that temperatures are not always lower at the northern sites. These graphs show mean air and water temperatures for each of the three experiments. In most cases, the coldest site is in the south.

# Summary - Transplants

- Growth rates were not lower at the northern transplant sites
- Temperatures were not consistently colder with increasing latitude
- Cold stress does not determine the northern range limit.

# Coastal Ocean Currents




Direction of Ocean Current

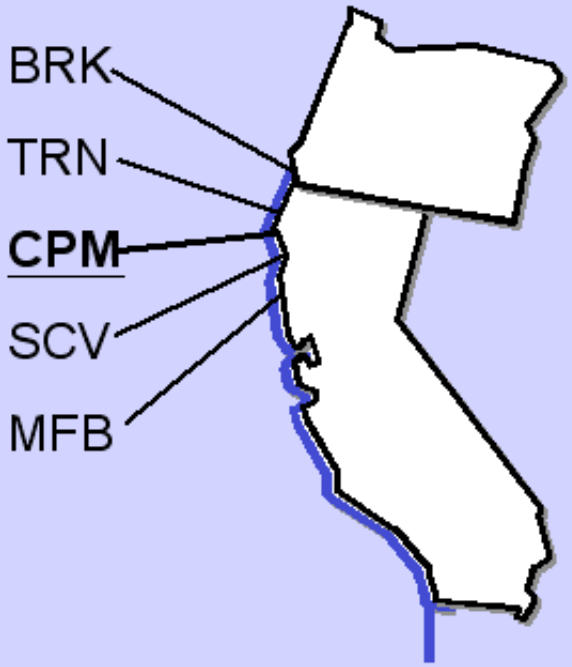
If adults can survive and grow just fine at sites north of Cape Mendocino, why are the snails so rare at these sites?

One possible explanation is that ocean currents prevent the larvae of *M. scabra* from dispersing north of Cape Mendocino. Since adult snails are sedentary, movement of individuals occurs during a 2 week larval phase in the ocean.

Pt. Conception near Santa Barbara in southern California is known to act as a dispersal barrier in this way. Two ocean currents converge in this area, pushing water offshore and reducingthe transport of larvae across the Point.

Although the oceanography around Cape Mendocino is poorly studied, currents around could be acting in a similar way, preventing the northwards dispersal of *M. scabra* larvae across the Cape.

# Recruitment Survey




**RATIONALE:**

***If there is a dispersal barrier at Cape Mendocino:***

Recruitment rates at CPM and sites north will be lower than south of CPM

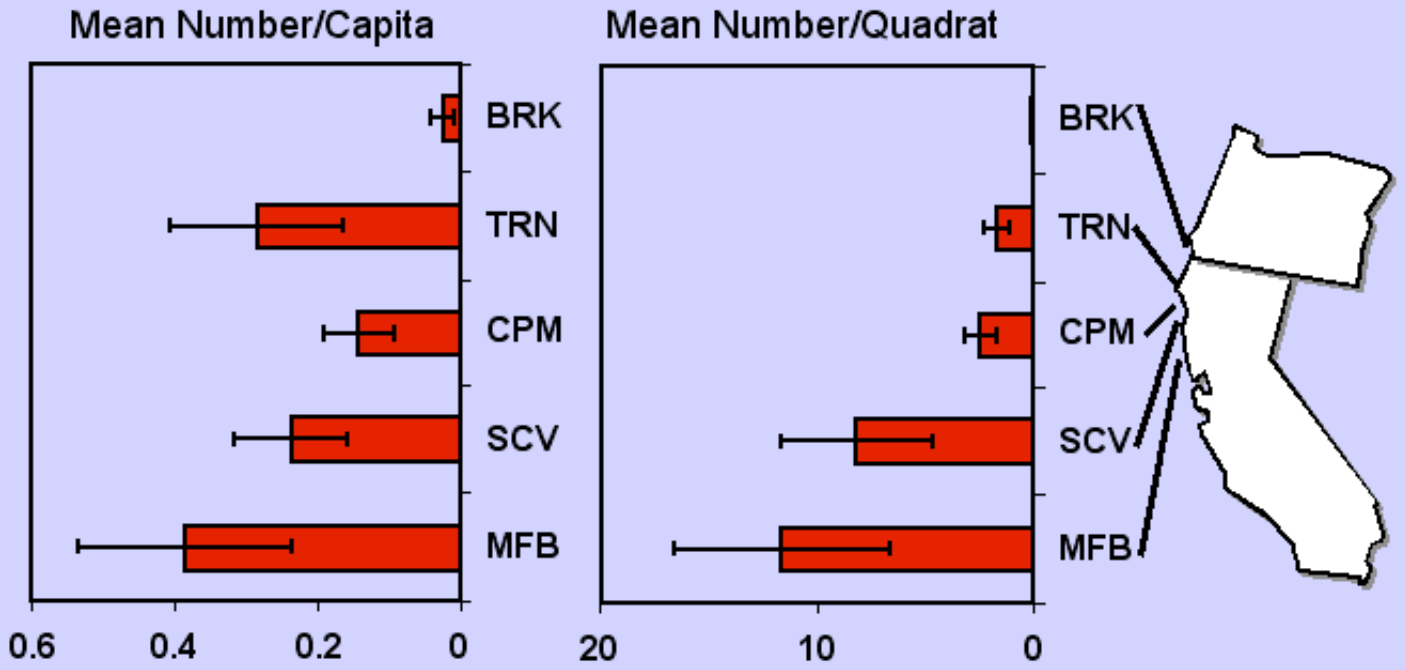
***If there is no dispersal barrier:***

Recruitment rates will be similar at all sites, OR, recruitment will be proportional to adult abundance

To test for a dispersal barrier at Cape Mendocino, I am conducting monthly surveys of recruitment at five sites in Northern California and Southern Oregon. At each site I have permanently marked 10 - 30 25cm x 25cm quadrats. Each month I resurvey each quadrat and note the number of new recruits of *M. scabra*.

# Cumulative Recruitment

## June 2000 - Feb 2001




For the period fromJune 2000 to February 2001, I have plotted the average total number of recruits per quadrat at each site in the right plot above. Recruitment was significantly lower at the three northern sites (CPM, TRN, BRK) than at the two central sites. The left plot shows that recruitment at CPM is still significantly lower than sites to the south, even when the lower density of adults is accounted for. These results are consistent with hypothesis of a dispersal barrier near Cape Mendocino. This survey is continuing.

# Summary - Recruitment

- Absolute recruitment was lower at Cape Mendocino and site to the north.
- Per capita recruitment was lower at Cape Mendocino than either north or south.
- Ocean currents arround Cape Mendocino may act as a dispersal barrier for this species.

# Conclusions

For *Macclintockia scabra*:

- Transplant experiments did not show a role for climate.
- Recruitment data suggest that ocean currents may limit dispersal.

More generally:

- Temperatures do not always decrease with latitude. Local dynamics may be more important to species than the broad scale patterns.
- To predict species responses to climate change, we need to know more than just how temperature will change. (e.g. how will temperature changes affect ocean circulation?)